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CORRECTED APPEAL BRIEF AND PETITION FOR EXTENSION OF TIME

TITLE: Integration of Barrier Layer and Seed Layer
U.S. SERIAL NO.: 09/965,370
FILING DATE: September 26, 2001
INVENTOR: Chung, et al.
EXAMINER: Eric B. Fuller
GROUP ART UNIT: 1762
CONFIRMATION NO.: 6507

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BRIEF ON APPEAL
Serial No. 09/965,370
Page 2 of 28

TABLE OF CONTENTS

1.	Identification Page.....	1
2.	Table of Contents	2
3.	Real Party in Interest	3
4.	Related Appeals and Interferences	4
5.	Status of Claims	5
6.	Status of Amendments	6
7.	Summary of Claimed Subject Matter	7
8.	Grounds of Rejection to be Reviewed on Appeal	10
9.	Arguments	11
10.	Conclusion	19
11.	Claims Appendix	20
12.	Evidence Appendix	27
13.	Related Proceedings Appendix	28

NOV 09 2006

Patent
Att. Dkt. No. APPM/006303/CPI/COPPER/PJS

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES**

In re Application of:
Chung, et al.

Serial No.: 09/965,370

Confirmation No.: 6507

Filed: September 26, 2001

**For: Integration of Barrier Layer
and Seed Layer**

Group Art Unit: 1762

Examiner: Eric B. Fuller

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Keith M. Tackett, 32.008

CORRECTED APPEAL BRIEF

Applicants submit this Corrected Appeal Brief to the Board of Patent Appeals and Interferences on appeal from the decision of the Examiner of Group Art Unit 1762 dated April 28, 2006, finally rejecting claims 1-7, 9-10, 39, 42, and 44-69. The final rejection of claims 1-7, 9-10, 39, 42, and 44-69 is appealed. This Corrected Appeal Brief is believed to be timely by mailing on or before the extended due date of November 18, 2006. Authorization to charge the one month extension of time fee for filing this Corrected Appeal Brief is provided on a separate fee transmittal. Please charge any additional fees that may be required to make this Corrected Appeal Brief timely and acceptable to Deposit Account No. 20-0782/APPM/006303/KMT.

479509-1

BRIEF ON APPEAL
Serial No. 09/965,370
Page 3 of 28

Real Party in Interest

The present application has been assigned to Applied Materials, Inc., 3050 Bowers Avenue, Santa Clara, California 95054.

BRIEF ON APPEAL
Serial No. 09/065,370
Page 4 of 28

Related Appeals and Interferences

Applicant asserts that no other appeals or interferences are known to the Applicant, the Applicant's legal representative, or assignee which will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

BRIEF ON APPEAL
Serial No. 09/966,370
Page 5 of 28

Status of Claims

Claims 1-7, 9-10, 39, 42, and 44-69 are pending in the application. Claims 1-69 were originally presented in the application. Claims 8, 11-38, 40-41, and 43 have been cancelled without prejudice.

Claims 1-7, 9-10, 39, 42, and 44-69 stand finally rejected as discussed below. The final rejection of claims 1-7, 9-10, 39, 42, and 44-69 is appealed.

BRIEF ON APPEAL
Serial No. 09/965,370
Page 6 of 28

Status of Amendments

All claim amendments have been entered by the Examiner. Amendments to the claims presented after the final rejection have been entered by the Examiner and included in the Claims Appendix.

BRIEF ON APPEAL
Serial No. 09/965,370
Page 7 of 28

Summary of Claimed Subject Matter

In the embodiments of independent claim 1, a method for filling a feature is provided, comprising depositing a barrier layer 204 by atomic layer deposition (see, paragraphs 27-28 from page 6, line 21, to page 7, line 4, and Figures 2B and Figures 5A-5C), the barrier layer 204 having a thickness less than about 50 Å (see, paragraph 42, at page 11, lines 5-13 and paragraph 74 at page 20, lines 15-17), depositing a seed layer 502 over the barrier layer 204, the seed layer 502 comprising copper and a metal selected from the group consisting of aluminum, magnesium, zirconium, and combinations thereof (see, paragraph 53 at page 13, lines 21-31 and paragraph 62 at page 17, lines 4-15), and then depositing a copper conductive material layer over the seed layer (see, paragraph 53, page 13, lines 21-31, and paragraph 61, at page 16, lines 28-31).

In the embodiments of independent claim 39, a method of preparing a substrate structure for copper metallization is provided, comprising depositing a barrier layer by atomic layer deposition to a sidewall coverage of about 50 Å or less (see, paragraphs 27-29 at page 6, lines 21-32 and at page 7, lines 1-17, and paragraph 42, at page 11, lines 5-12), and then depositing a seed layer over the barrier layer, the seed layer comprising copper and a metal selected from the group consisting of aluminum, magnesium, zirconium, and combinations thereof (see, paragraph 53 at page 13, lines 21-31 and paragraph 62 at page 17, lines 4-15).

In the embodiments of independent claim 42, a method of filling a feature is provided, comprising depositing a barrier layer by atomic layer deposition, the barrier layer having a thickness of less than about 20 Å (see, paragraphs 27-29 at page 6, lines 21-32 and at page 7, lines 1-17), depositing a copper alloy seed layer over the barrier layer (see, paragraph 53 at page 13, lines 21-31 and paragraph 62 at page 17, lines 4-15), the copper alloy seed layer comprising copper and a metal in a concentration between about 0.01 atomic percent and 5.0 atomic percent (see, paragraph 53 at page 13, lines 21-31), the metal selected from the group consisting of aluminum, magnesium, zirconium, and combinations thereof (see, paragraph 53 at page 13, lines 21-31 and

BRIEF ON APPEAL
Serial No. 09/965,370
Page 8 of 28

paragraph 62 at page 17, lines 4-15), and then depositing a copper conductive material layer over the copper alloy seed layer (see, paragraph 53 at page 13, lines 21-31 and paragraph 61 at page 16, lines 28-32).

In the embodiments of independent claim 47, a method of filling a feature is provided, comprising depositing a barrier layer by atomic layer deposition, the barrier layer having a thickness less than about 20 Å (see, paragraphs 27-29 at page 6, lines 21-32 and at page 7, lines 1-17), depositing a copper alloy seed layer over the barrier layer (see, paragraph 55 at page 14, lines 26-33), the copper alloy seed layer comprising copper and a metal in a concentration between about 0.01 atomic percent and 5.0 atomic percent (see, paragraph 55 at page 14, lines 26-33 and at page 15, lines 1-11), the metal selected from the group consisting of aluminum, magnesium, zirconium, and combinations thereof (see, paragraph 55 at page 14, lines 26-33); depositing a second seed layer over the copper alloy seed layer (see, paragraph 55 at page 14, lines 26-33), and then depositing a copper conductive material layer over the second seed layer (see, paragraph 55 at page 14, lines 26-33 and at page 15, lines 1-11, and paragraph 61 at page 16, lines 28-32).

In the embodiments of independent claim 53, a method of filling a feature is provided, comprising depositing a barrier layer by atomic layer deposition, the barrier layer having a thickness less than about 20 Å (see, paragraphs 27-29 at page 6, lines 21-32 and at page 7, lines 1-17), depositing a first seed layer over the barrier layer to a sidewall coverage between a sub-monolayer and about 50 Å (see, paragraphs 57-58 at page 15, lines 18-33 and at page 16, line 1), the first seed layer comprising aluminum (see, paragraph 57 at page 15, lines 18-25), depositing a second seed layer over the first seed layer (see, paragraph 57 at page 15, lines 18-25), and depositing a conductive material layer over the second seed layer (see, paragraph 57 at page 15, lines 18-25 and paragraph 61 at page 16, lines 28-32).

In the embodiments of independent claim 59, a method of preparing a substrate structure for electroplating of copper is provided, comprising depositing a barrier layer by atomic layer deposition, the barrier layer having a thickness less than about 20 Å

BRIEF ON APPEAL
Serial No. 09/965,370
Page 9 of 28

(see, paragraphs 27-29 at page 6, lines 21-32 and at page 7, lines 1-17), and depositing a seed layer over the barrier layer, the seed layer comprising copper and aluminum (see, paragraph 53 at page 13, lines 21-31 and paragraph 62 at page 17, lines 4-15).

BRIEF ON APPEAL
Serial No. 09/965,370
Page 10 of 28

Grounds of Rejection to be Reviewed on Appeal

1. Claims 1-7, 9-10, 39, 42, and 44-69 stand rejected under 35 USC § 103(a) as being obvious over *Lopatin et al.* (U.S. Patent No. 6,368,954) in view of *Lopatin et al.* (U.S. Patent No. 6,174,799).

2. Claims 42 and 44-69 stand rejected under 35 USC § 103(a) as being obvious over *Lopatin et al.* '954 in view of *Lopatin et al.* '799, and in further view of *Tsai et al.* (U.S. Patent No. 6,309,964).

BRIEF ON APPEAL
Serial No. 09/965,370
Page 11 of 28

ARGUMENTS

I. Rejection under 35 U.S.C. § 103(a) over *Lopatin et al.* '954 in view of *Lopatin et al.* '799

Claims 1-7 and 9-10

Claims 1-7 and 9-10 stand rejected under 35 U.S.C. § 103(a) as being obvious over *Lopatin et al.* '954 in view of *Lopatin et al.* '799. The Examiner states that *Lopatin et al.* '954 teaches a barrier layer of 20-300 angstroms formed by atomic layer deposition and *Lopatin et al.* '799 teaches nitrogen grading in copper alloyed seed layers to increase adhesion to the barrier layer and decrease electro-migration. The Examiner states that it would have been obvious to use the constituents of the seed layer of *Lopatin et al.* '799 in the process of *Lopatin et al.* '954 to reap the benefits of the bulk copper layer having better adhesion to the barrier layer and decreased electro-migration.

Applicants have respectfully traversed the rejection based on the failure of *Lopatin et al.* '954 in view of *Lopatin et al.* '799 to teach or suggest all the limitations of the claimed subject matter. *Lopatin et al.* '954 teaches a barrier layer of 20-300 angstroms formed by atomic layer deposition (ALD), a pre-seed layer comprising copper formed by atomic layer epitaxy, and a seed layer comprising copper formed by chemical vapor deposition (CVD). *Lopatin et al.* '799 teaches a method depositing a seed layer over a barrier layer, the seed layer comprises a conductive metal material alloyed with a nitrided metal material, having a graded nitrogen content.

However, *Lopatin et al.* '954 in view of *Lopatin et al.* '799 does not teach, suggest, or motivate depositing of a seed layer, which comprises copper and a metal selected from the group consisting of aluminum, magnesium, zirconium, and combinations thereof, to be deposited over a thin barrier layer which is deposited by atomic layer deposition to a thickness of less than about 50 Å. The Examiner has failed to show a clear and particular motivation by the skilled artisan to select from the disclosures of *Lopatin et al.* '954 and *Lopatin et al.* '799. The only suggestion is provided in the Applicant's disclosure and thus hindsight.

BRIEF ON APPEAL
Serial No. 09/985,370
Page 12 of 28

Applicant submits that "[t]he showing of a motivation to combine must be clear and particular, and it must be supported by actual evidence. In *re Dembiczak*, 50 U.S.P.Q. 2d 1614, 1617 (Fed. Cir. 1999). The Federal Circuit has also ruled that "[o]ne cannot use hindsight reconstruction to pick and choose among isolated disclosures in the prior art to deprecate the claimed invention." (In *re Fritch* at 1784). The only suggestion of the claimed subject matter is provided in the Applicant's disclosure, and thus the claims were rejected in hindsight.

Applicant asserts that a copper alloyed seed layer recited in claims 1-7 and 9-10 to be deposited over a thin ALD deposited barrier layer is not taught or suggested in the combination of *Lopatin et al.* '954 in view of *Lopatin et al.* '799. Accordingly, *Lopatin et al.* '954 in view of *Lopatin et al.* '799, alone or in combination, does not teach, show, or suggest depositing a barrier layer by atomic layer deposition, the barrier layer having a thickness less than about 50 Å, depositing a seed layer over the barrier layer, the seed layer comprising copper and a metal selected from the group consisting of aluminum, magnesium, zirconium, and combinations thereof, and then depositing a copper conductive material layer over the seed layer, as recited in claim 1 and claims dependent thereon. Withdrawal of the rejection is respectfully requested.

Claim 39

Claim 39 stands rejected under 35 U.S.C. § 103(a) as being obvious over *Lopatin et al.* '954 in view of *Lopatin et al.* '799. Applicants have respectfully traversed the rejection based on the failure of *Lopatin et al.* '954 in view of *Lopatin et al.* '799 to teach or suggest all the limitations of claim 39.

Lopatin et al. '954 in view of *Lopatin et al.* '799 does not teach, suggest, or motivate depositing of a seed layer, which comprises copper and a metal selected from the group consisting of aluminum, magnesium, zirconium, and combinations thereof, to be deposited over a thin barrier layer which is deposited by atomic layer deposition to a sidewall coverage of about 50 Å or less. The Examiner has failed to show a clear and particular motivation by the skilled artisan to select from the disclosures of *Lopatin et al.* '954 and *Lopatin et al.* '799. In addition, *Lopatin et al.* '954 in view of *Lopatin et al.* '799,

BRIEF ON APPEAL
Serial No. 09/965,370
Page 13 of 28

alone or in combination, does not teach, show, or suggest a barrier layer deposited to a sidewall coverage of about 50 Å or less.

Accordingly, *Lopatin et al.* '954 in view of *Lopatin et al.* '799, alone or in combination, does not teach, show, or suggest depositing a barrier layer by atomic layer deposition to a sidewall coverage of about 50 Å or less, and then depositing a seed layer over the barrier layer, the seed layer comprising copper and a metal selected from the group consisting of aluminum, magnesium, zirconium, and combinations thereof, as recited in claim 39. Withdrawal of the rejection is respectfully requested.

Claims 42, 44-46

Claims 42, 44-46 stand rejected under 35 U.S.C. § 103(a) as being obvious over *Lopatin et al.* '954 in view of *Lopatin et al.* '799. Applicants have respectfully traversed the rejections based on failure of *Lopatin et al.* '954 in view of *Lopatin et al.* '799 to teach or suggest all the limitations of the claim 42 and claims dependent thereon.

Lopatin et al. '954 and *Lopatin et al.* '799 have been discussed above. In addition, *Lopatin et al.* '954 in view of *Lopatin et al.* '799, alone or in combination, does not teach, show, or suggest depositing a copper alloy seed layer comprising copper and a metal in a concentration between about 0.01 atomic percent and 5.0 atomic percent.

Accordingly, *Lopatin et al.* '954 in view of *Lopatin et al.* '799, alone or in combination, does not teach, show, or suggest depositing a barrier layer by atomic layer deposition, the barrier layer having a thickness of less than about 20 Å, depositing a copper alloy seed layer over the barrier layer, the copper alloy seed layer comprising copper and a metal in a concentration between about 0.01 atomic percent and 5.0 atomic percent, the metal selected from the group consisting of aluminum, magnesium, zirconium, and combinations thereof, and then depositing a copper conductive material layer over the copper alloy seed layer, as recited in claim 42 and claims dependent thereon. Withdrawal of the rejection is respectfully requested.

Claims 47-52

Claims 47-52 stand rejected under 35 USC § 103(a) as being obvious over *Lopatin et al.* '954 in view of *Lopatin et al.* '799. Applicants have respectfully traversed

BRIEF ON APPEAL
Serial No. 08/965,370
Page 14 of 28

the rejections based on failure of *Lopatin et al.* '954 in view of *Lopatin et al.* '799 to teach or suggest all the limitations of the claim 47 and claims dependent thereon.

Lopatin et al. '954 and *Lopatin et al.* '799 have been discussed above. In addition, *Lopatin et al.* '954 in view of *Lopatin et al.* '799, alone or in combination, does not teach, show, or suggest a copper alloy seed layer comprising copper and a metal in a concentration between about 0.01 atomic percent and 5.0 atomic percent. Further, *Lopatin et al.* '954 in view of *Lopatin et al.* '799, alone or in combination, does not teach, show, or suggest a second copper seed layer to be deposited over a copper alloy seed layer comprising copper and a metal.

Accordingly, *Lopatin et al.* '954 in view of *Lopatin et al.* '799, alone or in combination, does not teach, show, or suggest depositing a barrier layer by atomic layer deposition, the barrier layer having a thickness less than about 20 Å, depositing a copper alloy seed layer over the barrier layer, the copper alloy seed layer comprising copper and a metal in a concentration between about 0.01 atomic percent and 5.0 atomic percent, the metal selected from the group consisting of aluminum, magnesium, zirconium, and combinations thereof, depositing a second seed layer over the copper alloy seed layer, and then depositing a copper conductive material layer over the second seed layer, as recited in claim 47 and claims dependent thereon. Withdrawal of the rejection is respectfully requested.

Claims 53-58

Claims 53-58 stand rejected under 35 U.S.C. § 103(a) as being obvious over *Lopatin et al.* '954 in view of *Lopatin et al.* '799. Applicants have respectfully traversed the rejections based on failure of *Lopatin et al.* '954 in view of *Lopatin et al.* '799 to teach or suggest all the limitations of the claim 53 and claims dependent thereon.

Lopatin et al. '954 and *Lopatin et al.* '799 have been discussed above. In addition, *Lopatin et al.* '954 in view of *Lopatin et al.* '799, alone or in combination, does not teach, show, or suggest a first seed layer comprising aluminum. Furthermore, *Lopatin et al.* '954 in view of *Lopatin et al.* '799, alone or in combination, does not teach, show, or suggest a second seed layer deposited over a first seed layer comprising aluminum. Still further, *Lopatin et al.* '954 in view of *Lopatin et al.* '799, alone or in

BRIEF ON APPEAL
Serial No. 09/965,370
Page 15 of 28

combination, does not teach, show, or suggest a first aluminum seed layer deposited to a sidewall coverage between a sub-monolayer and about 50 Å to be deposited over a thin barrier layer having a thickness of less than about 20 Å.

Accordingly, *Lopatin et al.* '954 in view of *Lopatin et al.* '799, alone or in combination, does not teach, show, or suggest depositing a barrier layer by atomic layer deposition, the barrier layer having a thickness less than about 20 Å, depositing a first seed layer over the barrier layer to a sidewall coverage between a sub-monolayer and about 50 Å, the first seed layer comprising aluminum, depositing a second seed layer over the first seed layer, and depositing a conductive material layer over the second seed layer, as recited in claim 53 and claims dependent thereon. Withdrawal of the rejection is respectfully requested.

Claims 59-69

Claims 59-69 stand rejected under 35 U.S.C. § 103(a) as being obvious over *Lopatin et al.* '954 in view of *Lopatin et al.* '799. Applicants have respectfully traversed the rejections based on failure of *Lopatin et al.* '954 in view of *Lopatin et al.* '799 to teach or suggest all the limitations of the claim 59 and claims dependent thereon.

Lopatin et al. '954 and *Lopatin et al.* '799 have been discussed above. In addition, *Lopatin et al.* '954 in view of *Lopatin et al.* '799, alone or in combination, does not teach, show, or suggest a seed layer comprising copper and aluminum to be deposited over a barrier layer deposited by ALD to a thickness of less than about 20 Å.

Accordingly, *Lopatin et al.* '954 in view of *Lopatin et al.* '799, alone or in combination, does not teach, show, or suggest depositing a barrier layer by atomic layer deposition, the barrier layer having a thickness less than about 20 Å, and depositing a seed layer over the barrier layer, the seed layer comprising copper and aluminum, as recited in claim 59 and claims dependent thereon. Withdrawal of the rejection is respectfully requested.

BRIEF ON APPEAL
Serial No. 09/965,370
Page 16 of 28

II. Rejection under 35 USC § 103(a) over *Lopatin et al.* '954 in view of *Lopatin et al.* '799, and in further view of *Tsai et al.*

Claims 42, 44-46

Claims 42, 44-46 stand rejected under 35 U.S.C. § 103(a) as being obvious over *Lopatin et al.* '954 in view of *Lopatin et al.* '799, and in further view of *Tsai et al.* The Examiner states that *Tsai et al.* teaches a barrier layer being effective at a thickness of 10 angstroms and it would be obvious to use a thickness of 10 angstroms for the barrier layer as taught by an ALD process of *Lopatin et al.* '954. Applicants have respectfully traversed the rejections based on failure of *Lopatin et al.* '954 in view of *Lopatin et al.* '799, and in further view of *Tsai et al.* to teach or suggest all the limitations of the claim 42 and claims dependent thereon.

Tsai et al., as stated by the Examiner, discloses only a barrier layer of 10-500 angstroms. Combination of *Tsai et al.* with *Lopatin et al.* '954 and *Lopatin et al.* '799 does not disclose, suggest or motivate the subject matter as claimed in claims 42 and 44-69 or any element lacking in the combination of *Lopatin et al.* '954 and *Lopatin et al.* '799, as discussed above. For example, *Tsai et al.*, does not disclose, suggest or motivate depositing a copper alloy seed layer comprising copper and a metal in a concentration between about 0.01 atomic percent and 5.0 atomic percent to be deposited over a barrier layer having a thickness of less than about 20 Å, as lacking in the combination of *Lopatin et al.* '954 and *Lopatin et al.* '799. Accordingly, withdrawal of the rejection is respectfully requested.

Claims 47-52

Claims 47-52 stand rejected under 35 U.S.C. § 103(a) as being obvious over *Lopatin et al.* '954 in view of *Lopatin et al.* '799, and in further view of *Tsai et al.* Applicants have respectfully traversed the rejections based on failure of *Lopatin et al.* '954 in view of *Lopatin et al.* '799, and in further view of *Tsai et al.* to teach or suggest all the limitations of the claim 47 and claims dependent thereon.

Tsai et al. discloses only a barrier layer of 10-500 angstroms. *Tsai et al.* in combination with *Lopatin et al.* '954 and *Lopatin et al.* '799 does not disclose, suggest or motivate the subject matter as claimed in claims 47-52 or any element lacking in the

BRIEF ON APPEAL
Serial No. 09/965,370
Page 17 of 28

combination of *Lopatin et al.* '954 and *Lopatin et al.* '799, as discussed above. For example, *Tsai et al.*, does not disclose, suggest or motivate a metal in a concentration between about 0.01 atomic percent and 5.0 atomic percent to be deposited in a copper alloy seed layer comprising copper and the metal, as lacking in the combination of *Lopatin et al.* '954 and *Lopatin et al.* '799. In addition, *Tsai et al.*, does not disclose, suggest or motivate a second copper seed layer deposited over a copper alloy seed layer comprising copper and a metal in a concentration between about 0.01 atomic percent and 5.0 atomic percent. Accordingly, withdrawal of the rejection is respectfully requested.

Claims 53-58

Claims 53-58 stand rejected under 35 U.S.C. § 103(a) as being obvious over *Lopatin et al.* '954 in view of *Lopatin et al.* '799, and in further view of *Tsai et al.* Applicants have respectfully traversed the rejections based on failure of *Lopatin et al.* '954 in view of *Lopatin et al.* '799, and in further view of *Tsai et al.* to teach or suggest all the limitations of the claim 53 and claims dependent thereon.

Tsai et al. discloses only a barrier layer of 10-500 angstroms. *Tsai et al.* in combination with *Lopatin et al.* '954 and *Lopatin et al.* '799 does not disclose, suggest or motivate the subject matter as claimed in claims 53-58 or any element lacking in the combination of *Lopatin et al.* '954 and *Lopatin et al.* '799, as discussed above. For example, *Tsai et al.*, does not disclose, suggest or motivate a first seed layer comprising aluminum. In addition, *Lopatin et al.* '954 in view of *Lopatin et al.* '799, and in further view of *Tsai et al.*, alone or in combination, does not teach, show, or suggest a second seed layer deposited over a first seed layer comprising aluminum. Further, *Lopatin et al.* '954 in view of *Lopatin et al.* '799, and in further view of *Tsai et al.*, alone or in combination, does not teach, show, or suggest a first aluminum seed layer deposited to a sidewall coverage between a sub-monolayer and about 50 Å to be deposited over a thin barrier layer of a thickness of less than about 20 Å, as lacking in the combination of *Lopatin et al.* '954 and *Lopatin et al.* '799. Accordingly, withdrawal of the rejection is respectfully requested.

BRIEF ON APPEAL
Serial No. 09/965,370
Page 19 of 28

CONCLUSION

The Examiner errs in finding that it would have been obvious to include a nitrogen graded copper alloyed seed layer as taught by *Lopatin et al.* '799 to be deposited over an ALD deposited barrier layer as disclosed by *Lopatin et al.* '954 to reject claims 1-7, 9-10, 39, 42, and 44-69 because *Lopatin et al.* '954 in view of *Lopatin et al.* '799, alone or in combination, does not teach, suggest, or motivate a seed layer comprising copper and a metal selected from the group consisting of aluminum, magnesium, zirconium, and combinations thereof to be deposited over a barrier layer, the barrier layer having a thickness less than about 50 Å and deposited by atomic layer deposition.

The Examiner further errs in finding that it would have been obvious to include a barrier layer at a thickness of 10 angstroms as taught by *Tsai et al.* to be combined in an ALD deposited barrier layer as disclosed by *Lopatin et al.* '954 in view of a nitrogen graded copper alloyed seed layer as taught by *Lopatin et al.* '799 to reject claims 42 and 44-69 because *Lopatin et al.* '954 in view of *Lopatin et al.* '799, and in further view of *Tsai et al.*, alone or in combination, does not teach, suggest, or motivate a copper alloy seed layer comprising copper and a metal in a concentration between about 0.01 atomic percent and 5.0 atomic percent, the metal selected from the group consisting of aluminum, magnesium, zirconium, and combinations thereof to be deposited over a barrier layer, the barrier layer having a thickness less than about 20 Å and deposited by atomic layer deposition.

Respectfully submitted,



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BRIEF ON APPEAL
Serial No. 09/865,370
Page 18 of 28

Claims 59-69

Claims 59-69 stand rejected under 35 U.S.C. § 103(a) as being obvious over *Lopatin et al.* '954 in view of *Lopatin et al.* '799, and in further view of *Tsai et al.* Applicants have respectfully traversed the rejections based on failure of *Lopatin et al.* '954 in view of *Lopatin et al.* '799, and in further view of *Tsai et al.* to teach or suggest all the limitations of the claim 59 and claims dependent thereon.

Tsai et al. discloses only a barrier layer of 10-500 angstroms. *Tsai et al.* in combination with *Lopatin et al.* '954 and *Lopatin et al.* '799 does not disclose, suggest or motivate the subject matter as claimed in claims 59-69 or any element lacking in the combination of *Lopatin et al.* '954 and *Lopatin et al.* '799, as discussed above. For example, *Tsai et al.*, does not disclose, suggest or motivate a seed layer comprising copper and aluminum to be deposited over a thin barrier layer deposited by ALD to a thickness of less than about 20 Å, as lacking in the combination of *Lopatin et al.* '954 and *Lopatin et al.* '799. Accordingly, withdrawal of the rejection is respectfully requested.

BRIEF ON APPEAL
Serial No. 09/965,370
Page 20 of 28

CLAIMS APPENDIX

1. (Previously Presented) A method of filling a feature, comprising:
depositing a barrier layer by atomic layer deposition, the barrier layer having a thickness less than about 50 Å;
depositing a seed layer over the barrier layer, the seed layer comprising copper and a metal selected from the group consisting of aluminum, magnesium, zirconium, and combinations thereof; and then
depositing a copper conductive material layer over the seed layer.
2. (Original) The method of claim 1, wherein the seed layer comprises a copper alloy seed layer of the copper and the metal.
3. (Original) The method of claim 1, wherein the seed layer comprises a first seed layer deposited over the barrier layer and a second seed layer deposited over the first seed layer.
4. (Original) The method of claim 3, wherein the first seed layer comprises a copper alloy seed layer of the copper and the metal.
5. (Original) The method of claim 4, wherein the second seed layer comprises undoped copper.
6. (Original) The method of claim 3, wherein the first seed layer comprises the metal.
7. (Original) The method of claim 6, wherein the second seed layer comprises undoped copper.
8. (Canceled)

BRIEF ON APPEAL
Serial No. 09/965,370
Page 21 of 28

9. (Original) The method of claim 1, wherein the seed layer is deposited by a technique selected from the group consisting of physical vapor deposition, chemical vapor deposition, atomic layer deposition, electroless deposition, and combinations thereof.

10. (Original) The method of claim 1, wherein the copper conductive material layer is deposited by a technique selected from the group consisting of electroplating, electroless deposition, chemical vapor deposition, physical vapor deposition, and combinations thereof.

11-38. (Cancelled)

39. (Previously Presented) A method of preparing a substrate structure for copper metallization, comprising:

depositing a barrier layer by atomic layer deposition to a sidewall coverage of about 50 Å or less; and then

depositing a seed layer over the barrier layer, the seed layer comprising copper and a metal selected from the group consisting of aluminum, magnesium, zirconium, and combinations thereof.

40-41. (Cancelled)

42. (Previously Presented) A method of filling a feature, comprising:

depositing a barrier layer by atomic layer deposition, the barrier layer having a thickness of less than about 20 Å;

depositing a copper alloy seed layer over the barrier layer, the copper alloy seed layer comprising copper and a metal in a concentration between about 0.01 atomic percent and 5.0 atomic percent, the metal selected from the group consisting of aluminum, magnesium, zirconium, and combinations thereof; and then

depositing a copper conductive material layer over the copper alloy seed layer.

BRIEF ON APPEAL
Serial No. 09/965,370
Page 22 of 28

43. (Canceled)

44. (Original) The method of claim 42, wherein the barrier layer comprises a material selected from the group consisting of titanium, titanium nitride, titanium silicon nitride, tantalum, tantalum nitride, tantalum silicon nitride, tungsten, tungsten nitride, tungsten silicon nitride, and combinations thereof.

45. (Original) The method of claim 42, wherein the copper alloy seed layer is deposited by a technique selected from the group consisting of physical vapor deposition, chemical vapor deposition, atomic layer deposition, electroless deposition, and combinations thereof.

46. (Original) The method of claim 42, wherein the copper conductive material layer is deposited by a technique selected from the group consisting of electroplating, electroless deposition, chemical vapor deposition, physical vapor deposition, and combinations thereof.

47. (Previously Presented) A method of filling a feature, comprising:
depositing a barrier layer by atomic layer deposition, the barrier layer having a thickness less than about 20 Å;
depositing a copper alloy seed layer over the barrier layer, the copper alloy seed layer comprising copper and a metal in a concentration between about 0.01 atomic percent and 5.0 atomic percent, the metal selected from the group consisting of aluminum, magnesium, zirconium, and combinations thereof;
depositing a second seed layer over the copper alloy seed layer; and then
depositing a copper conductive material layer over the second seed layer.

48. (Original) The method of claim 47, wherein the barrier layer comprises a material selected from the group consisting of titanium, titanium nitride, titanium silicon nitride, tantalum, tantalum nitride, tantalum silicon nitride, tungsten, tungsten nitride, tungsten silicon nitride, and combinations thereof.

BRIEF ON APPEAL
Serial No. 09/965,370
Page 23 of 28

49. (Original) The method of claim 47, wherein the second seed layer comprises undoped copper.

50. (Original) The method of claim 47, wherein the copper alloy seed layer is deposited by a technique selected from the group consisting of physical vapor deposition, chemical vapor deposition, atomic layer deposition, electroless deposition, and combinations thereof.

51. (Original) The method of claim 47, wherein the second seed layer is deposited by a technique selected from the group consisting of physical vapor deposition, chemical vapor deposition, atomic layer deposition, electroless deposition, and combinations thereof.

52. (Original) The method of claim 47, wherein the copper conductive material layer is deposited by a technique selected from the group consisting of electroplating, electroless deposition, chemical vapor deposition, physical vapor deposition, and combinations thereof.

53. (Previously Presented) A method of filling a feature, comprising:
depositing a barrier layer by atomic layer deposition, the barrier layer having a thickness less than about 20 Å;
depositing a first seed layer over the barrier layer to a sidewall coverage between a sub-monolayer and about 50 Å, the first seed layer comprising aluminum;
depositing a second seed layer over the first seed layer; and
depositing a conductive material layer over the second seed layer.

54. (Original) The method of claim 53, wherein the barrier layer comprises a material selected from the group consisting of titanium, titanium nitride, titanium silicon nitride, tantalum, tantalum nitride, tantalum silicon nitride, tungsten, tungsten nitride, tungsten silicon nitride, and combinations thereof.

BRIEF ON APPEAL
Serial No. 09/965,370
Page 24 of 28

55. (Original) The method of claim 53, wherein the second seed layer comprises undoped copper.

56. (Original) The method of claim 53, wherein the first seed layer is deposited by a technique selected from the group consisting of physical vapor deposition, chemical vapor deposition, atomic layer deposition, electroless deposition, and combinations thereof.

57. (Original) The method of claim 53, wherein the second seed layer is deposited by a technique selected from the group consisting of physical vapor deposition, chemical vapor deposition, atomic layer deposition, electroless deposition, and combinations thereof.

58. (Original) The method of claim 53, wherein the copper conductive material layer is deposited by a technique selected from the group consisting of electroplating, electroless deposition, chemical vapor deposition, physical vapor deposition, and combinations thereof.

59. (Previously Presented) A method of preparing a substrate structure for electroplating of copper, comprising:

depositing a barrier layer by atomic layer deposition, the barrier layer having a thickness less than about 20 Å; and

depositing a seed layer over the barrier layer, the seed layer comprising copper and aluminum.

60. (Original) The method of claim 59, wherein the seed layer comprises a copper alloy seed layer of the copper and the aluminum, the aluminum present in the copper alloy seed layer in a concentration between about 0.001 atomic percent and about 5.0 atomic percent.

BRIEF ON APPEAL
Serial No. 09/965,370
Page 25 of 28

61. (Original) The method of claim 60, wherein the copper alloy seed layer comprises the aluminum in a concentration between about 0.01 atomic percent and about 2.0 atomic percent.

62. (Original) The method of claim 60, wherein the copper alloy seed layer comprises the aluminum in a concentration between about 0.1 atomic percent and about 1.0 atomic percent.

63. (Original) The method of claim 59, wherein the seed layer comprises a first seed layer deposited over the barrier layer and a second seed layer deposited over the first seed layer.

64. (Original) The method of claim 63, wherein the first seed layer comprises a copper alloy seed layer of the copper and the aluminum, the aluminum present in the copper alloy seed layer in a concentration between about 0.001 atomic percent and about 5.0 atomic percent and wherein the second seed layer comprises undoped copper.

65. (Original) The method of claim 64, wherein the copper alloy seed layer comprises the aluminum in a concentration between about 0.01 atomic percent and about 2.0 atomic percent.

66. (Original) The method of claim 64, wherein the copper alloy seed layer comprises the aluminum in a concentration between about 0.1 atomic percent and about 1.0 atomic percent.

67. (Original) The method of claim 63, wherein the first seed layer comprises aluminum to a sidewall coverage between a sub-monolayer and about 50 Å and wherein the second seed layer comprises undoped copper.

BRIEF ON APPEAL
Serial No. 09/965,370
Page 26 of 28

68. (Original) The method of claim 59, wherein the barrier layer comprises a material selected from the group consisting of titanium, titanium nitride, titanium silicon nitride, tantalum, tantalum nitride, tantalum silicon nitride, tungsten, tungsten nitride, tungsten silicon nitride, and combinations thereof.

69. (Original)The method of claim 59, wherein the seed layer is deposited by a technique selected from the group consisting of physical vapor deposition, chemical vapor deposition, atomic layer deposition, electroless deposition, and combinations thereof.

BRIEF ON APPEAL
Serial No. 09/965,370
Page 27 of 28

EVIDENCE APPENDIX

No evidence is submitted.

BRIEF ON APPEAL
Serial No. 09/965,370
Page 28 of 28

RELATED PROCEEDINGS APPENDIX

No copies of decisions rendered by a court or the Board in the related appeal or interference listed on page 4 of this Brief are included as there have been no related appeal or interference listed on page 4 of this Brief.